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Tutorial Paper:
What is Information and Communication Technology?

Abstract:

The phrases Information Technology (IT) Communication Technology (CT) are in common usage. More recently, the phrase Information and Communication Technology (ICT) has come into vogue. The origin and meanings of IT and CT are discussed and the process of convergence, leading to ICT, is discussed. Focus is on a general audience rather than a specialised audience.

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1. INTRODUCTION

The phrase information and communication technology, or ICT, has become a buzzword when talking about the technology, the applications and the benefits of information and telecommunications in all spheres of endeavour. It is therefore important that as we plan to integrate ICT in all the university functions, all users, that is students, academic staff, administration, and management, have got a clear understanding of what is meant by ICT.

The motivation here is not just a focus on technology, but rather an attempt to demystify what are often regarded as highly advanced technological devices and solutions. ICT must, in the end, become as ubiquitous as the ordinary telephone: Everyone knows what it is; everyone can use it; but most people neither know nor care to know how it works.

This paper discusses in general terms information and its usage, the tools used in information handling and management, and the tools used in its dissemination, the telecommunication networks. The evolution of information technology, telecommunication technology, and their convergence are reviewed, and common terms used are explained.

The paper is presented in six sections:

- Introduction
- Historical perspective
- Information technology
- Communication technology
- Convergence: ICT
- Internet and Intranet

2. HISTORICAL PERSPECTIVE

Information and telecommunication have played an important role throughout the evolution of all species. It was known right from the start that information about our surroundings gives us a better chance of survival. What is edible? What is dangerous? What do the changes in the weather signify? Who is the enemy? Each individual in the community would gather bits and pieces of data and information about these and other aspects of their environment. Clearly, information not passed on is information lost. Communication within each species therefore gradually developed, getting more and more advanced as the complexity of the information to be passed on increased.

Families developed into communities, and communities covered increasingly large areas. For communities covering large areas, it was no longer viable to communicate verbally, through say shouting, especially in emergencies (translating normally to danger). The need for long distance communication, or telecommunication, was appreciated very early in human community development (tele – at a distance). Smoke signals, drums, runners, carrier pigeons, semaphores: all these played a crucial role at one stage in telecommunications, ensuring that vital information could be rapidly transmitted from one person or community to another. We are therefore not dealing with a new concept when we talk about information and telecommunications, even if in our modern conceit we often think so. We are just talking about new methods, ways and tools (technology) of doing what we have always done.

3. INFORMATION TECHNOLOGY

We are always collecting data, consciously and sometimes subconsciously. The ages, heights, and weights of people in a group; the speed of a vehicle; marks scored in assignments; the number of students in the university; the number and classification of books in the library: this data is consciously collected. Subconsciously, the body monitors, for example, the "temperature", and a decision is made to move away from a hot place. We therefore accumulate masses and masses of data.

This poses several challenges: storage; access; analysis; presentation. Analysis is critical in that it reduces data to information, based on which decisions can be taken. A collection of one hundred sets of marks is just data. If this is analysed to get averages and other statistics, information about performance is obtained. Poor performance leads to a management decision: investigate, establish the cause of poor performance; and take corrective action.

Over the ages, human beings have tried many ingenious ways of storing and processing information. Knots in ropes for storage; the spike abacus (still used) for data manipulation; and other less or more advanced techniques. It is not surprising that the most readily available counter, the digits on our fingers, led to the establishment of the count which goes to ten, and that still pervades all our systems. The count to ten and multiples thereof (decimal system) was convenient even when electrical methods of storing data came into fashion.

In electrical and electronic systems, it however became very unwieldy and expensive to represent the ten states implicit in the decimal system. On the other hand, it is very easy to represent a two-state, or binary, system using electrical or electronic devices. A switch has, for example got two states: on or off. The same applies to a light. Counting using binary digits therefore came into vogue (for the technologists), especially with the advent of electronic storage and processing devices. With parallel developments in microelectronics, it became possible to pack millions of devices in a square centimeter because we are only concerned with two states: off or on; 0 or 1. The device that has made this possible is the transistor. When it was invented just over forty years ago, it was a veritable dinosaur compared to its current size.

Complex processes of computation, analysis, and indeed thought processes, are broken down into very simple steps through programming. Programmers translate our high level needs into simple routines that a computer can execute - very fast. Some of these are specific programs for specific research or a specific piece of work. Others are general application programs, like word processing and spread sheet packages. These sit between the user and the real computer, making life generally very easy. Since the computer lives in the binary world and we live in the more complex world of numerals, literal and trans-literal characters, data and information are always translated into our world before it is displayed on the monitor or printed out.

The millions of devices execute the simple steps, some in sequence and some simultaneously. Apparently complex feats are therefore achieved in unbelievably short times. Not really surprising: we have seen what a large swarm of locusts can do to a country the size of Uganda overnight.

The large number of devices handling the same process clearly needs a parade commander who tells them when to move. This is the clock. A clock speed of say 300 MHz means that each of the millions of devices is able to execute 300,000,000 simple steps per seconds. A machine with a clock of 600MHz will do the same job in about half the time. For the last twenty years or so, this speed has been doubling every 18 months.

We can therefore look at the computer as a very efficient abacus, albeit billions of times faster, and using binary instead of decimal arithmetic: A computer, by its very name, was originally just an arithmetic device. The modern computer has, in addition to its arithmetic function, storage (permanent memory, for example the hard disk drive), memory where data can reside temporarily (random access memory, or RAM), a keyboard for convenience of data entry and control, and a display for feedback and presentation to the user.

The use of systems based on binary digital arithmetic for data acquisition, storage, and analysis has added advantages: storage space is reduced; and data acquisition as well as analysis are much cheaper and faster. Currently, the word digital, with all its connotations of trendy; speed; accuracy, is almost invariably used to mean binary digital.

The hardware, the software, the methods, and the know-how required or used in acquiring, storing, processing, and displaying data and information is collectively known as Information Technology, IT.

4. COMMUNICATION TECHNOLOGY

For a very long time, telecommunication was about sending the equivalent of voice messages and alphanumeric characters over long distances. This initially required a physical medium, a conductor that could carry an electric current connecting the two points between which telecommunication was required. The morse code, one of the earliest attempts at efficient transmission of alphanumeric characters, found wide usage in telegraphy. The development of electronics and communication theory led to technologies that were able to transmit several signals on the same wire simultaneously. Telegraph and telephone cables were laid across continents and oceans. Telecommunication engineers relentlessly pursued their dream: ***the death of distance***.

This was an exciting era for physics. Marconi demonstrated that messages could be transmitted for very long distances through space by the use of electromagnetic waves, which are exactly the same as light, only that they cannot be perceived by our eyes. Radio and radio communication systems were born. Entrepreneurs seized the opportunity to branch off into the audio mass media – radio broadcasting. Signals could be transmitted around the globe. A tool for information gathering and propaganda dissemination was born. Goebbels used this for the Nazi Germany propaganda machine with impressive, albeit notorious, results.

The second world war, like all wars, was a great spur to developments in telecommunication and its usage. It had been theoretically demonstrated that an object at about 36,000 km above the earth would rotate at the same speed, and therefore appear stationary. The Sputnik went up in the fifties, though not as high. The idea of satellites became a reality. Satellite based communication systems were born, and the world became a smaller place. More and more capacity was demanded by the peoples of the world. More and more satellites have been sent

up, and still the capacity cannot expand fast enough. It is rapidly becoming a junk yard up there.

Satellite platforms are however very expensive, and the marginal cost of increasing capacity is very high. A solution appeared in the form of optical fibres. Made from the most ubiquitous material, sand (of a very high purity) optical fibres carry signals in the form of light pulses generated by lasers (optical generators and amplifiers). A "1" is the presence of a light pulse; a "0" is the absence of a light pulse. Pulses are generated at the rate a typical rate of 1,000,000,000 pulses per second, enough to transmit 20,000 simultaneous phone conversations on a fibre less than one millimeter overall diameter. Hundreds of thousand of kilometers of optical fibres have been laid across the oceans and continents, providing the information superhighway. The dream of the telecommunication engineer has almost come true: In real terms, distance related cost are negligible compared to other network costs. ***Distance has died***.

Communication is not just about the channel. The telecommunication engineer worries about:

- Fidelity: is the signal received a true replica of what was sent?
- Efficiency: is the maximum possible amount of information being transmitted through the available channel?
- Cost effectiveness: Is the acceptable level of fidelity being achieved at the lowest possible cost?

Techniques have been developed to combat noise, which is naturally present in all systems, so that fidelity is improved. The signal is analysed and modified at the source so that it can be reconstructed with the least amount of transmitted data. Efficient methods of using available resources are developed so that the overhead cost on each transmitted bit is minimised. Methods of packing more bits in available channels are developed.

The hardware, the know-how, the programs and the methods used in ensuring that the message is transmitted correctly, efficiently and cost-effectively are collectively known as Communication Technology, CT.

5. CONVERGENCE: INFORMATION AND COMMUNICATION TECHNOLOGY

In the early days of the computers, total centralisation was the norm. Behemoths, known as main frames, would occupy some centralised location on say a campus, and the users would have to move to the computer. This was the IBM paradigm. The peak of this was around the late seventies and early eighties. Computers were therefore for academia, especially the science based, the military, and certain industries.

It was however recognised, even at this stage, that it would be convenient to access the main frame from a distance, instead of going with decks of cards to the main card reader. RJE for Remote Job Entry became common. Dumb terminals were set up for accessing main frames where all the processing power resided. While the demands on the communication channels were modest, we can see here the beginning of convergence. Even within the computer room, good reliable communication was required between the different devices. Information technology required communication channels.

At the same time, advances in communication technology called for complexity in signal processing never anticipated. A communication network required the abilities of data acquisition, storage and processing to operate. Communication technology needed information technology.

In the late seventies and early eighties, companies like Apple and others came up with a new paradigm: the ubiquitous computer, available to individuals: the standalone personal computer (PC) was born.

The environment was right: advanced techniques of data gathering and processing were developing; efficient ways of communication were being implemented; enterprises, both public and private were becoming global. Computing power could be widely afforded. It was only logical that synergy be created between IT and CT. Each benefits from and reinforces the other. There is no point in gathering and rapidly processing information that cannot be transmitted as fast. There is no point in high capacity channels if they cannot be used to full capacity. IT and CT started moving together, and we now talk about ***Information and Communication Technology, ICT.***

Maybe we need a new name for the modern computer, because it is really no longer just a computer. It is also a communication terminal that can be used as a telephone, a facsimile (fax) or a video communicator. It can be used as a typewriter, an entertainment center, a house help, a guard, and a spy. All in one box.

6. INTERNETS AND INTRANETS

The convergence of IT and CT into ICT really means that the concept of linking computers together into networks evolved. An enterprise would, for example, have small networks of computers, one for each functional department. This facilitates the sharing of resources like software, printers, and data. It also facilitates easy communication. The next stage up is to link the small networks to other networks in the enterprise. This creates an internetwork, a network of networks or, in short, an internet.

This is all very well for an enterprise where technology and other things can be dictated. What happens when enterprises across the world try to link up? A Tower of Babel because, from the machine point of view, there is no common language or accepted norm for communication. This was the case until a common protocol, the Internet Protocol (IP) combined with the Transmission Control Protocol (TCP) were evolved. We therefore talk about TCP/IP, a set of ground rules that must be obeyed by all machines in order to communicate with each other over a common network.

What is the Internet?

Advances in information and communication technologies and the need to share information globally led to the evolution of the Internet. What is popularly called the Internet is really a network of many independent internets linked together for mutual benefit. The Internet is a global connection of computers. These computers are connected via a huge network of telecommunications links. The Internet allows access to a wide resource of data and

information stored at different sites (called **hosts** or **servers**) and locations all around the world. Each computer connected to the Internet can act as a host.

What makes up the Internet?

The Internet consists of hosts and interconnecting equipment such as routers and telecommunication links that interconnect routers and hosts together.

A **host** is a computer on the Internet. Each host is capable of acting as a provider of information, such as files, documents or images. A host can also access information on another host if it has the required permission to do so.

A **router** is a device that joins telecommunications links and groups of computers together. It provides a mechanism for determining a **route** (or path) between the two computers that want to exchange information.

Commercial providers sell connectivity via optical fibres and satellites. Others set up hosts providing data or free email services for users. The pay back is from other enterprises that advertise on such sites and quietly build profiles of users for targeted advertising. Like any community, each person (read computer and communication hardware) that joins must be given a name, for example makerere.ac.ug. This is the only way information and communication requests can be properly routed.

The popular cartoon has two dogs at a computer terminal talking to each other: *"On the internet, nobody knows you are a dawg!"*

What sort of features or services does the Internet provide?
The Internet is a platform for a wide range of services, some of which are listed in Table 1.

Table 1

Services over the Internet

Service	Description of Service
EMAIL	Electronic mail. Permits the sending and receiving of messages to other users connected to the Internet.
FTP	File Transfer Protocol. A means of sending and receiving files from one computer to another.
Electronic Commerce	Commercial and financial transactions initiated and closed via one's communication terminal (computer, phone, etc)
USENET NEWS	A number of discussion groups that allow users to post questions and replies, sorted by topic. Also known as news.
WWW	World Wide Web. Accessed using a web browser such as Netscape Navigator or Internet Explorer, a means of locating and displaying information located on the Internet.

Like many beneficial projects, serious research on internet communication came from the military. The idea was to establish a mode of communication that would not fail due to a massive military strike. The cold war has had its benefits.

What is An Intranet?

For the sake of distinction, an internet internal to an enterprise is called an intranet, but its nature and that of the internet (apart from diverse ownership) is the same.

7. CONCLUSION

Information and communication technology is about achieving the age-old objectives and applications of information and communication in new and more efficient ways. ICT is not an end in itself. It is just a means to the end. The challenge to all of us is really not necessarily to understand it, but to appreciate it and its effectiveness in increasing the efficiency of our operations. It is the authors' hope that this paper has gone some way in imparting the minimum amount of technological awareness required for the full appreciation of the benefits of ICT. We hope the myth is exploded.